REPORT A67-26

DERUSTING CORROSION SPECIMENS
Stannous Chloride As An Acid Derusting Inhibitor

by

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March 1967

AMCMS Code 5025.11.294
DA Project 1C024401A328

DEPARTMENT OF THE ARMY
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

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Reprinted from

Vol. 6, No. 3
pp. 45-46
(1967) March

MATERIALS PROTECTION

AN
OFFICIAL PUBLICATION
NATIONAL ASSOCIATION
of
CORROSION ENGINEERS

2400 West Loop South
Houston, Texas 77027

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The authors discuss the use of an inhibitor in acid derusting of corrosion test specimens to prevent attack of the underlying metal. Emphasized is the action of stannous chloride as an inhibitor in the acid derusting process. Test data are given to substantiate the performance of the inhibitor.

CORROSION TESTING of steel specimens by the weight-loss method requires removal of corrosion products without harming the underlying metal. The sodium hydride descaling process, often used for this purpose, involves immersion of the rusted specimens in a bath of molten sodium hydroxide containing 1.5% to 2% sodium hydride—formed by reaction of sodium with hydrogen in the molten salt bath.[1]

While acid pickling solutions are more conveniently, simple, and safely used for derusting, the ferric ions released at the metal-solution interface during rust dissolution aggravates attack of the specimens by cathodic depolarization. Usual pickling inhibitors, effective for retarding acid attack of steel, are relatively ineffective when substantial amounts of ferric ions are present in the acid.

A report has been published which indicates that addition of stannous ions to acid-pickling solutions (containing ferric ions) result in chemical reduction to ferrous, thereby eliminating the cause of additional corrosive attack of pickled steel.[2] The present investigation was conducted to verify this fact and to determine the effectiveness of stannous ion additions to acid pickling solutions for rust removal as an alternative to the sodium hydride descaling process.

Stannous Chloride Addition

Solutions were prepared of 3.5 M hydrochloric acid containing 0.1, 0.2, and 0.4 M ferric chloride with various additions of stannous chloride. Weighed 2 by 2-inch specimens of bare steel (AISI Type 1010), in duplicate, were immersed in the solutions at 25 C (77 F) for four hours. The specimens were then water rinsed, dried, and weighed to determine the degree of attack.

The presence of ferric ions in these hydrochloric acid concentrations had a profound effect in increasing the dissolution rate of the steel. The addition of stannous chloride, however, decreased the dissolution rates (Figure 1). Proceeding according to the Equation $2Fe^{+3} + Sn^{+2} = 2Fe^{+2} + Sn^{+4}$, a given molar quantity of stannous chloride was capable of complete reduction of double the molar quantity of ferric ion.

Stannous chloride, in addition to nullifying the corrosive activity of the ferric ion on the dissolution of steel, is itself an acid pickling inhibitor, probably functioning by overvoltage modification.

Three Derusting Procedures

The effectiveness of stannous chloride in retarding the acid dissolution of steel during rust removal was determined. Experiments were performed with weighted AISI Type 1010 steel panels (4 by 6-inch) which had been exposed for 11 months to the industrial atmosphere at Frankford Arsenal, Philadelphia, Pa.

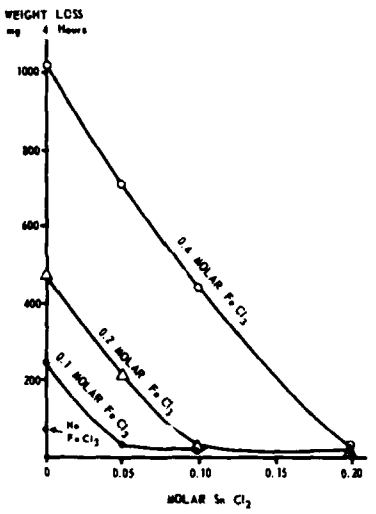

Figure 1—Effect of $SnCl_2$ additions to 3.5 M HCl containing $FeCl_3$ on dissolution rate of steel panels (2 by 2-inch). The addition of stannous chloride decreased the dissolution rates.

The panels were heavily rusted with deeply embedded rust in corrosion cavities. Preliminary tests showed that between one and two hours immersion in 3.5 M HCl was necessary for complete removal of rust.

Divided into three groups of eight each, the panels were subjected to one of the following derusting procedures:

1. Immersion in sodium hydride bath at 400 C (752 F) for 60 minutes.

2. Immersion in eight liters of 3.5 M HCl containing one gram per liter pickling inhibitor (95% efficient inhibitor of the heterocyclic nitrogen class) at 25 C (77 F) for two hours.

3. Immersion in eight liters of 3.5 M HCl containing one gram per liter pickling inhibitor (same as above) and 0.2 M mole per liter of $SnCl_2$ at 25 C (77 F) for two hours.

An unexposed weighed bare steel panel, free of rust, was included as a control in each of the three groups and immersed in the derusting solution together with the rusted panels.

Results

All three derusting procedures effectively removed rust from even the deepest pits, and it was assumed that the sodium hydride process provided rust removal without loss of sound metal. Thus, the data developed from the specimens descaled in the sodium hydride bath can be used as a reference for comparing effectiveness of other derusting systems.

It is evident from the data shown in Table 1 that the eight test panels (4 by 6-inch) lost an average of 14.932 grams of metal per panel as a result of corrosion during atmospheric exposure. This was assumed to be the true corrosion weight loss after the specimens had been cleaned in the sodium hydride bath.

The use of inhibited hydrochloric acid solution for derusting a similar group of test panels resulted in weight losses averaging 16.013 grams. Evidently, over one gram of the sound metal was attacked because of the liberation of ferric ion at the metal-rust interface. The use of inhibited acid for rust removal resulted in an apparent corrosion weight loss which exceeded the true corrosion weight loss by over 7%.

When stannous chloride was added to the inhibited hydrochloric acid, the average loss of the atmospherically exposed panels was 15.396 grams. This corresponds to a weight loss of about 3.1% in excess of that observed for the sodium hydride descaled panels. This is an improvement over the use of inhibited acid without stannous chloride, but still indicated some of the sound metal had been attacked.

Unexposed bare steel panels (4 by 6-inch) treated in the same solution and at the same time as the rusted panels were tested for weight loss. The weight loss produced by immersion in the sodium hydride bath was negligible and in the stannous-containing acid solution was only about 0.001 gram per panel.

However, the conventional inhibited acid solution progressively increased the dissolution rate of the bare steel as ferric ions were liberated by dissolution of the rust from the atmospherically exposed panels, so that by the end of the 2-hour immersion period a total of 0.078 gram of metal was dissolved.

Additional weighed bare steel panels were immersed in the acid-pickling solutions for two hours after removal of the derusted panels. The inhibited acid solution containing stannous chloride still removed only about 0.001 gram per

panel. The weight loss of a bare steel panel in the inhibited acid solution without stannous chloride increased to 0.140 gram. In addition, much of the rust which had spalled from the surface of the rusted panels during pickling had not yet dissolved. It was thus evident that continued use of this pickling solution would result in an ever increasing weight loss measurement error due to increased attack of sound metal by the increasing concentration of ferric ions.

Conclusions

Stannous ions are effective for the reduction of ferric ions in acid solution. The effect of ferric chloride in increasing the acid dissolution rate of steel is thus nullified by the addition of stannous chloride.

The addition of stannous chloride to an inhibited hydrochloric acid solution markedly reduces metal attack during pickling of rusted steel. Such a solution offers promise for supplanting the sodium hydride bath as a means of rust removal for corrosion testing.

The relatively small error in corrosion weight loss measurements produced by sound metal attack can probably be minimized by scraping off corrosion products and by impregnating rust-covered specimens with concentrated stannous chloride solution before pickling.

Acknowledgment

The authors thank V. P. Pearson and C. G. Boulles, Inland Steel Co. for derusting specimens in sodium hydride and A. Gallaccio, Frankford Arsenal, and S. K. Coburn, U. S. Steel Corp. for helpful comments.

References

1. *Metal Finishing Guidebook Directory*, 1966, p. 167.
2. S. G. Clarke, *Trans Electrochem. Soc.*, 69, 131 (1936).

TABLE 1—Effect of Derusting Baths on Weight Loss of Steel Panels (4 by 6-inch) Atmospherically Exposed at Frankford Arsenal.

	CORROSION WEIGHT LOSS AFTER DERUSTING, GRAMS		
SPECIMENS	SODIUM HYDRIDE PROCESS (ONE HOUR AT 400 C)	3.5 M HCl 1 g l INHIBITOR[1] (TWO HOURS AT 25 C)	3.5 M HCl 1 g l INHIBITOR[1] 0.2 M $SnCl_2$ (TWO HOURS AT 25 C)
1	14.791	15.603	15.521
2	15.038	16.370	15.433
3	14.528	15.459	14.807
4	14.672	15.898	15.341
5	14.886	15.659	15.327
6	14.496	16.470	15.760
7	15.435	16.249	15.163
8	15.615	16.403	15.820
Average	14.932	16.013	15.396
Standard Deviation	0.383	0.380	0.304
Percent Error	0 (assumed)	7.2	3.1
Bare Steel Controls During Derusting	0.000	0.078	0.001
Bare Steel Controls After Derusting	0.000	0.140	0.001

(1) Heterocyclic nitrogen compound

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Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
FRANKFORD ARSENAL Philadelphia, Pa. 19137	Unclassified
	2b. GROUP

3. REPORT TITLE

DERUSTING CORROSION SPECIMENS
Stannous Chloride As An Acid Derusting Inhibitor

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Research Reprint

5. AUTHOR(S) (First name, middle initial, last name)

PEARLSTEIN, Fred
WEIGHTMAN, Robert F.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1967	7	2

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
AMCMS Code 5025.11.294 b. PROJECT NO. DA Project 1C024401A328 c. d.	Report A67-26 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	MUCOM

13. ABSTRACT

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DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Derusting Corrosion Testing Ferric Chloride Stannous Chloride						